Experiment 9

DENSITY

EQUIPMENT

1 ERROR Program
1 SPHERE VOLUME program
3 regularly shaped objects of uniform density
2 irregularly shaped objects of uniform density (small & large)
1 100 ml graduated cylinder
1 overflow can
1 triple beam balance
1 vernier caliper
tap water

INTRODUCTION

The purpose of this experiment is to calculate the densities of various objects and water by finding the mass for a given volume of each.

Density is one characteristic of a substance that can be used to distinguish it from another substance. Density is a measure of the compactness of matter. It is determined by the masses and spacing of the atoms in a substance. More precisely, it is the amount of matter per unit volume. The formula for density is:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The mass of an object can be measured using a triple beam balance. The volume is the amount of space occupied by the object. If the object is a regularly shaped solid, appropriate measurement and calculation can determine its volume.

In Experiment 1 we calculated the volumes of several regularly shaped objects. Some of the formulas we used were: for a rectangular solid,

$$\text{Volume} = \text{Length} \times \text{Width} \times \text{Hei}$$

and for a sphere,

$$V = \frac{4}{3}\pi \times \left(\frac{D}{2}\right)^3.$$

Sometimes, however, the object whose volume we wish to find is irregularly shaped. To find the volume of such an object, the object is completely immersed in water and the volume of the water it displaces is equal to its volume. This procedure is called the *water displacement* method.

To find the density of a known volume of a liquid, the mass of the liquid can be measured and the density can then be calculated.

It is important to note that density is commonly expressed in units of grams per cubic centimeter (g/cm^3) or kilograms per cubic meter (kg/m^3).

Note that 1 cm^3 = 1 mL, and so no conversion between the two is necessary.

PROCEDURE

A. Determining the Density of Regularly Shaped Objects

1. Use the triple beam balance to measure the mass of three regularly shaped objects. Record the results in grams.
2. Use the caliper to measure the dimensions of rectangular objects and the diameters of spherical objects. Record these measurements in centimeters.
3. Use the measurements made in Step 2 and the computer to calculate the volumes of the objects in cm^3. You may use the SPHERE VOLUME program for the spherical objects.
4. Use the mass and volume values to calculate the density of each object. Record the results.
5. Use the calculated densities of the objects and the density table to identify the substances composing the objects. Record your findings.

Density Table

SOLID	DENSITY (gm/cm^3)
Aluminum	2.70
Brass	8.55
Copper	8.93
Gold	19.30
Iron	7.90
Lead	11.30
Tungsten	19.30
Pine Wood	0.40
LIQUID	**DENSITY (gm/cm^3)**
Alcohol	0.79
Mercury	13.60
Water	1.00

B. Determining the Density of Irregularly Shaped Objects

6. Measure and record the masses of two irregularly shaped objects. Measure the mass of a dry graduated cylinder. Record the value.

7. Determine the volume of each object using water displacement. Two methods are described below:

Method 1 (Small Objects)

- Fill a graduated cylinder with water (about 3/4 full). Read and record the volume of the water.
- Gently drop the object in the cylinder and record the new volume.
- Record the volume of water displaced as the volume of the object.

Method II (Large Objects)

- Place a cup beneath the spout of an overflow can.
- Fill the overflow can with water until the water begins to go through the spout.
- When the water stops coming out, remove the cup and place the graduated cylinder beneath the spout.
- Gently lower the object into the overflow can.
- When the water stops coming out of the spout, record the volume of the water in the graduated cylinder as the volume of the object.

C. Comparison of Volume-Finding Methods

8. Use the water displacement method to once again find the volume of one of the regularly shaped objects from part A.

9. Find the difference between this volume measurement and the one you made in part A.

D. Determining the Density of Water

10. Use the mass you found earlier of the dry graduated cylinder; re-record this on your data sheet.

11. Pour some water into the cylinder and record the volume of this water.

12. Measure and record the combined mass of the cylinder and water.

13. Find the difference between the combined mass and that of the dry cylinder. Record this difference as the mass of the water.

14. Use the mass and volume values to determine the density of the water.

15. Pour out the water from the graduated cylinder. Repeat steps 11-14 once more.

16. Determine the average value of the two trials. Record this value.

17. Find the percent error between your average value of the density of water (measured value) and the value given in the Density Table (true value).

Experiment 9
DATA SHEET

Name: ______________________

Section: ______________________

A. Determining the Density of Regularly Shaped Objects

Shape of Object	Mass of Object (g)	Dimensions of Object (cm)	Calculated Volume of Object (cm^3)	Calculated Density of Object (g/cm^3)	Substance
Sphere		Diameter =			
Silver prism*		______x______x______			
Gold prism*		______x______x______			

**note: silver and gold refers to the colors, not the substances!*

B. Determining the Density of Irregularly Shaped Objects

Mass of Dry Graduated Cylinder:___________g

Object Description	Mass of Object (g)	Volume of Water in Cylinder (cm^3)	Volume of Water in Cylinder with Object (cm^3)	Volume of Object (cm^3)	Calculated Density of Object (g/cm^3)
Small					
Large					

C. Comparison of Volume-Finding methods volume from Part C

Shape of Object	Volume From Part A	Volume From Water Displacement	Difference in Volumes

D. Determining the Density of Water

Trial	Mass of Dry Graduated Cylinder (g)	Mass of Cylinder and Water (g)	Mass of Water (g)	Volume of Water (cm^3)	Calculated Density of Water (g/cm^3)
1					
2					

Average density of water ______________

Percent Error of calculated density of water _________________

QUESTIONS

1. Compare the two methods used in parts A and C to find the volume of a regularly shaped object. Which method do you believe was more accurate? Why?

2. What are the most probable causes for error in your calculation of the density of water?

3. If you were given a hollow metal sphere, could you calculate the density of the metal by using the methods in this experiment? Why or why not?

4. How could you determine the density of your body?

5. What is the density of gold? One ounce of water has a volume of 28.3ml. What is the volume of one ounce of gold in ml?